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Table of contents

1)	Introduction	3
2)	Material and Methods.....	4
a.	Sampling.....	4
b.	Choice of analytic indicators	8
c.	Treatment of results.....	8
3)	Results for Kitoza.....	9
a.	Kitoza from beef.....	9
b.	Kitoza from pork.....	10
4)	Results for Lanhouin.....	11
5)	Results for Kong.....	14
6)	Conclusion.....	15
7)	Bibliography	16

1) Introduction

This deliverable reports the biochemical and nutritional criteria analyzed on traditional African products from Group 2:

- The Kitoza: salted and smoked or dried meat from Madagascar,
- The Lanhouin: salted and fermented fish from Benin
- The Kong: smoked fish from Senegal

The objective is to describe the attributes of the finished products manufactured using the traditional skills.

2) Material and Methods

a. Sampling

The sampling of products from group 2 was described in the deliverable 1.2.1.2 "SOP for sampling strategy for group 2".

➤ KITOZA

Sampling was done considering the variability identified during the prior surveys. The selected parameters were:

- Two processes:
 - Salted and smoked
 - Salted and dried
- Two types of meat:
 - Beef
 - Pork
- Three production zones:
 - Urban
 - Peri-urban
 - Rural
- Two collection levels:
 - Producers (P) who produce only salted/smoked Kitoza in urban and peri-urban areas
 - Producers for home consumption (PHC) who produce salted/dried Kitoza in urban and peri-urban areas and smoked Kitoza in rural areas

For this deliverable (and deliverables D1242, D1252 and D1262), 60 samples were collected as described in Figure 1.

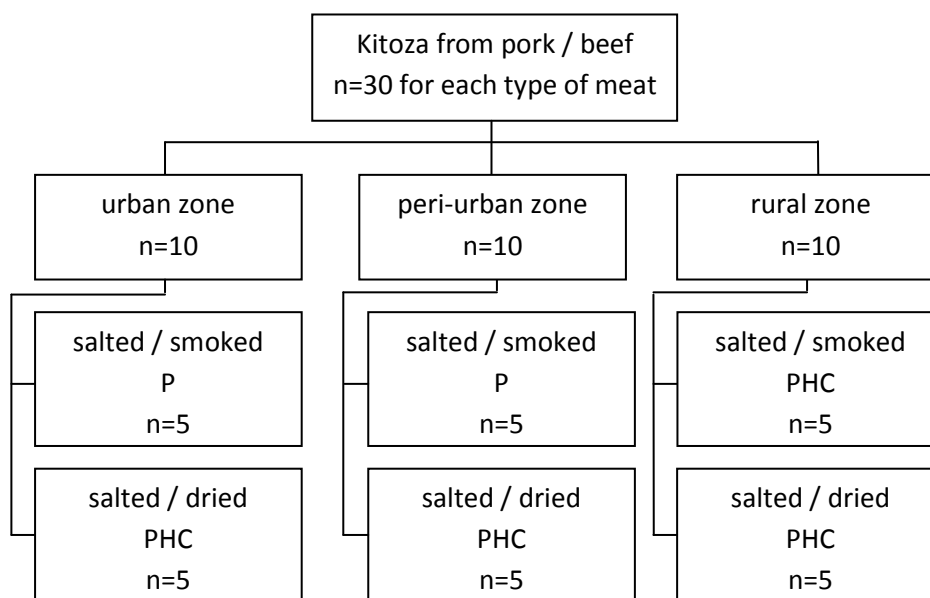


Figure 1: Diagram of the distribution and number of samples of Kitoza

(Legend of diagram: refer to variability of samples described above; n=number of samples)

➤ LANHOUIN

Sampling was done by considering the variability identified during the survey. The selected parameters were:

- Three processes according to unit operations and material used for fermentation:
 - Fermentation in aerobic conditions with basket used as fermentation material (FA)
 - Fermentation in micro-aerobic conditions with container or basket with cement layer, and can used as fermentation materials (FMA)
 - Fermentation in anaerobic conditions and without ripening (fish buried in the ground) (FAN)
- Two types of fish:
 - Lanhouin from Kingfish / Spanish mackerel which is a fatty fish (LK)
 - Lanhouin from Cassava croaker which is a lean fish (LC)
- Two collection levels
 - Processing sites with Processor (P) as actors
 - Markets with Wholesaler (W) and Retailer (R) as actors

For this deliverable (and deliverables D1242, D1252 and D1262), 30 samples were taken for each type of fish as described in Figure 2.

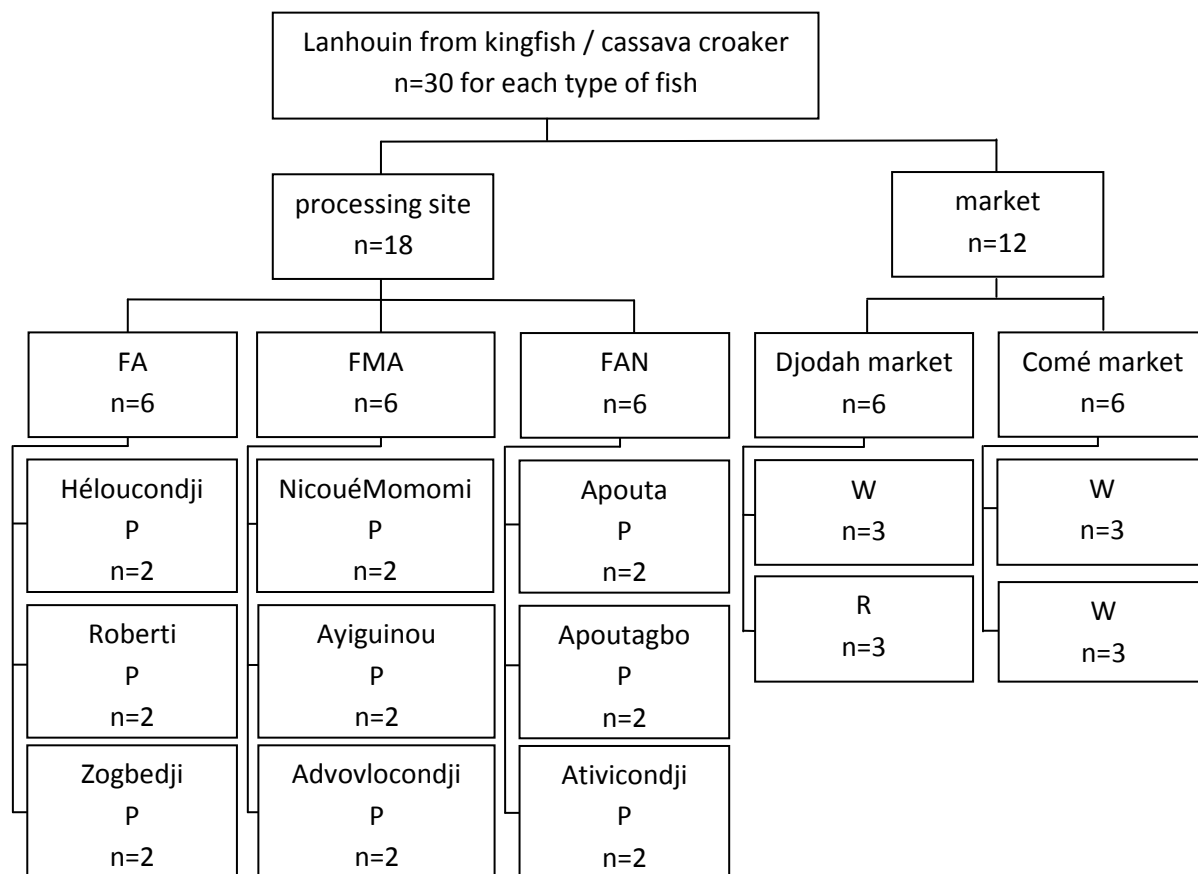


Figure 2: Diagram of the distribution and number of samples of Lanhouin

(Legend of diagram: refer to variability of samples described above; n=number of samples)

➤ KONG

Sampling was done considering the variability identified during the prior surveys. The retained parameters were the following:

- Two processes based on the degree of water content:
 - Well dried smoked Kong (D)
 - Wet smoked Kong (W)
- Two main production zones:
 - Urban zone of Dakar
 - Important Kong fishing's zone (Ziguinchor's region)

- Two types of collection level:

- Producers (P)
- Retailers (R)

For this deliverable (and deliverables D1242, D1252 and D1262), 35 samples were collected as described in Figure 3.

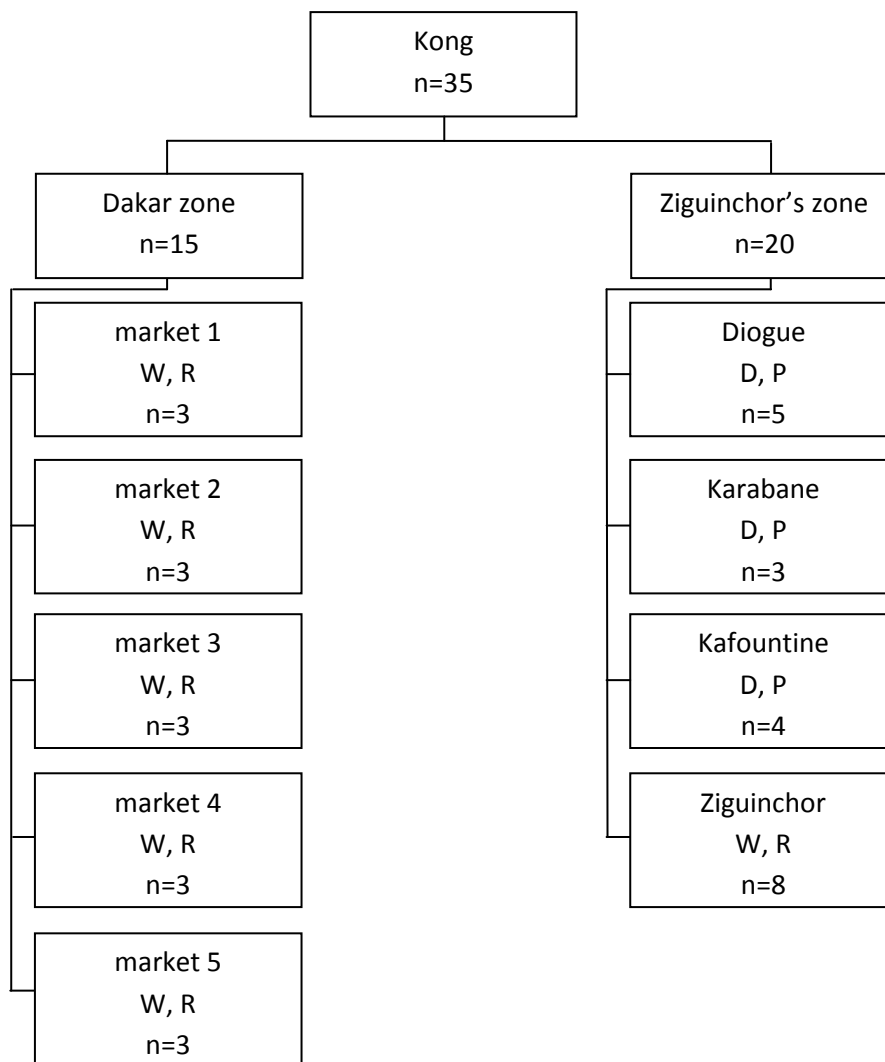


Figure 3: Diagram of the distribution and number of samples of Kong

(Legend of diagram: refer to variability of samples described above; n=number of samples)

b. Choice of analytic indicators

All laboratory analysis were conducted by the project partners by implementation of procedures of standardize methods (SOPs) specific to group 2 (deliverables of subtask 1.2.3). Because of the specific manufacturing processes by product type, the choice of analytical indicators was adapted for each product from group 2, as summarized in Table 1.

Table 1: Biochemical and nutritional analysis to evaluate the products of group 2

Indicator analyzed	Kitoza	Lanhouin	Kong
Protein	Nutri-MeatFish-001-fr	Nutri-MeatFish-001-fr	Nutri-MeatFish-001-fr
Lipid	Nutri-MeatFish-002-fr	Nutri-MeatFish-002-fr	Nutri-MeatFish-002-fr
TBARS	Anti-Nutri-MeatFish-002-fr	Anti-Nutri-MeatFish-002-fr	Anti-Nutri-MeatFish-002-fr
TVN	Not required	Anti-Nutri-MeatFish-003-fr	Not required
Acid index	Not required	Chem-MeatFish-008-fr	Chem-MeatFish-008-fr

For Kong, analyses were realized on 33 samples due to insufficient quantity of some samples. As it was shown that pH were not significantly different between wet and well dried Kong samples (cf D1.2.4.2), acid index measurements were not performed on Kong samples.

c. Treatment of results

For each of the biochemical and nutritional parameters studied, the mean and standard deviation (and minimum and maximum values for Kitoza) were calculated.

For each of the three products, the deliverable give tables where the results are given for the different processes of manufacture and, depending of the product, raw material and area of production. ANOVA were performed with Statistica program version 7.0 (StatSoft, USA). If a significant effect was found ($p < 0.05$), pairwise differences between groups were analyzed using Fisher's least-significant-difference test.

3) Results for Kitoza

a. Kitoza from beef

The results of biochemical and nutritional analysis of beef Kitoza samples are summarized in Table 2.

Table 2: Results for biochemical and nutritional analysis of beef Kitoza samples

Parameter and unit of measurement	Responsible partner and lab	Variety Process/Raw material/Area (Mean \pm SD)					
		Smoked samples (n=15)			Dried samples (n=15)		
		Mean \pm SD	Min	Max	Mean \pm SD	Min	Max
Protein (g/100g)	UT	40.2 \pm 9.1 ^b	24.3	62.4	49.8 \pm 9.6 ^a	37.16	70.8
Lipid (g/100g)	CIRAD-R	8.1 \pm 4.8 ^b	3.5	20.6	13.0 \pm 5.1 ^a	8.3	26.4
TBARS (mg MDA/kg)	CIRAD-R	2.14 \pm 3.29 ^a	0.10	12.16	4.64 \pm 3.72 ^a	0.79	14.89

n=number of samples; within one line different superscript letters indicate significant differences ($p < 0.05$)

Protein content varies from 24.3 to 70.8 g/100g. It is higher for dried Kitoza (49.8 \pm 9.6 g/100g) than for smoked ones (40.2 \pm 9.1 g/100g). There are no significant differences between samples from the different area except the dried Kitoza which has a higher protein content than smoked Kitoza from urban and periurban areas.

Lipid content of beef Kitoza varies from 3.5 to 26.4 g/100g. Dried Kitoza have a lipid content higher than smoked ones (13 \pm 5.1 g/100g and 8.1 \pm 4.8 g/100g respectively) ($p < 0.05$) and higher than lipid content of similar products: biltong and charqui (salted/dried beef) which have lipid contents of respectively 1.9 and 6.7% (Lewis *et al.*, 1957; Torres *et al.*, 1994). Lipid content of smoked Kitoza from several areas shows no significant differences. For dried Kitoza, only the urban one is significantly ($p < 0.05$) lower in fat than rural Kitoza. The results also show that Kitoza produced at the family level (smoked rural, dried urban, peri-urban and rural) have equivalent lipid contents.

TBARS values (indicator of lipid oxidation) of beef Kitoza range from 0.10 to 14.89 mg/kg with an average of 3.39 \pm 3.68 mg/kg.

b. Kitoza from pork

The results of biochemical and nutritional analysis of pork Kitoza samples are summarized in Table 3.

Table 3: Results for biochemical and nutritional analysis of pork Kitoza samples

Parameter and unit of measurement	Responsible partner and lab	Variety Process/Raw material/Area (Mean ± SD)					
		Smoked samples (n=15)			Dried samples (n=15)		
		Mean ± SD	Min	Max	Mean ± SD	Min	Max
Protein (g/100g)	UT	41.3±9.3 ^a	27.7	54.1	42.5±13.0 ^a	23.3	67.5
Lipid (g/100g)	CIRAD-R	17.4±6.1 ^a	7.2	28.7	18.9±12.6 ^a	7.3	51.8
TBARS (mg MDA/kg)	CIRAD-R	0.71±0.79 ^b	0.05	3.06	6.50±3.54 ^a	0.36	12.45

n=number of samples; within one line different superscript letters indicate significant differences (p<0.05)

Pork Kitoza have an average protein content of 41.9 ± 11.1 g/100g. It varies between 23.3 and 56.6 g/100g. There are no significant differences between smoked and dried Kitoza and between Kitoza classified according to their type and production area. Pork kitoza have a higher protein content than Unam- inung (salted/smoked pork meat product from Nigeria) (14.7-20.2 g/100g) (Solomon *et al.*, 1994).

Pork Kitoza have a lipid content of about 18.1 ± 9.8 g/100g. This content varies widely, from 7.2 to 51.8 g/100g. It is of the same order of lipid contents of similar meat products like boucané and unam-inung (salted/smoked pork) which are from 24.2 to 49.1 g/100g and 24.0 to 44.5 g/100g respectively (Poligné *et al.*, 2001 et Solomon *et al.*, 1994). There is no significant difference between smoked and dried Kitoza but there are differences between the groups of products classified according to their type and production area (p≤ 0.05). Dried Kitoza from the peri-urban area contains significantly more lipid (36.0 g/100g) than others. It is probably due to the raw material more than the transformation process.

TBARS values of pork Kitoza varies from 0.05 mg/kg to 12.45 mg/kg. Smoked Kitoza show lower (p<0.001) values (0.7 ± 0.8 mg/kg) than dried Kitoza (6.5 ± 3.5 mg/kg). For each, there are no significant differences between areas of production.

4) Results for Lanhouin

The results of biochemical and nutritional analysis of Lanhouin samples are summarized in Tables 4 and 5.

Table 4: Results for biochemical and nutritional analysis of Lanhouin market samples

Parameter and unit of measurement	Responsible partner and lab	Variety Process/Raw material/Area (Mean ± SD)			
		Comé market		Djoda market	
		Cassava fish (n=6)	Kingfish (n=6)	Cassava fish (n=6)	Kingfish (n=6)
Protein (g/100g)	UAC	21.8±3.5 ^a	21.6±1.8 ^a	24.7±3.8 ^b	22.8±3.5 ^b
Lipid (g/100g)	UAC	4.3±1.8 ^a	23.4±6.9 ^b	5.8±4.4 ^a	22.8±6.7 ^b
TBARS (mg MDA/kg)	UAC	12.3±1.2 ^a	11.1±1.0 ^a	11.8±1.3 ^a	11.4±1.1 ^a
TVN (mg N/100g)	UAC	225.8±80.2 ^a	262.8±78.9 ^b	208.0±58.7 ^a	296.2±80.0 ^b
Acidity index (g C18:1/100g)	UAC	0.80±0.76 ^a	2.45±0.33 ^b	0.76±0.27 ^a	2.52±0.74 ^b

n=number of samples; within one line different superscript letters indicate significant differences (p<0.05)

Table 5: Results for biochemical and nutritional analysis of Lanhouin processing sites samples

Parameter and unit of measurement	Responsible partner and lab	Variety Process/Raw material/Area (Mean ± SD)					
		Aerobic fermentation		Semi aerobic fermentation		Anaerobic fermentation	
		Cassava fish (n=6)	Kingfish (n=6)	Cassava fish (n=6)	Kingfish (n=6)	Cassava fish (n=6)	Kingfish (n=6)
Protein (g/100g)	UAC	22.9±2.5 ^b	23.5±1.8 ^b	23.3±4.4 ^b	23.3±2.2 ^b	24.7±3.2 ^b	21.5±0.9 ^b
Lipid (g/100g)	UAC	3.4±1.2 ^a	23.1±10.7 ^b	6.9±3.5 ^a	17.0±5.9 ^b	4.5±2.2 ^a	14.8±1.0 ^b
TBARS (mg MDA/kg)	UAC	12.2±0.7 ^a	11.6±1.3 ^a	12.5±0.4 ^a	11.5±1.4 ^a	10.9±2.1 ^a	11.5±1.4 ^a
TVN (mg N/100 g)	UAC	202.9±69.1 ^a	272.7±24.0 ^b	191.7±47.0 ^a	255.6±35.7 ^b	199.7±46.3 ^a	193.3±26.1 ^a
Acidity index (g C18:1/100g)	UAC	0.68±0.2 ^a	2.15±0.5 ^b	0.89±0.2 ^a	1.85±0.4 ^b	0.84±0.1 ^a	2.03±0.1 ^b

n=number of samples; within one line different superscript letters indicate significant differences (p<0.05)

The protein content varied from 21.8 ± 3.5 - 24.7 ± 3.8 and 21.5 ± 0.9 - 23.5 ± 1.8 g/100g in all samples prepared with cassava fish and kingfish respectively. No significant difference ($p > 0.05$) was observed in the protein content for all samples from markets and from processing sites. The protein content values obtained for all samples agreed with those reported on Lanhoun samples obtained with cassava fish (23.4 - 29.6 g/100g) and kingfish (20.9 - 28.3 g/100g) (Anihouvi *et al.*, 2006) and in Momoni in general (16.83 - 21.94 g/100g) (Sanni *et al.*, 2002) and Momoni samples made from kingfish (20.41 ± 1.4 %), Jackfish (21.46 ± 1.8 %) (Nketsia-Tabiri and Sefa-Dedeh 2000).

There was significant difference ($p < 0.05$) in the lipid content of cassava fish Lanhoun (3.4 ± 1.2 - 5.8 ± 4.4 g/100g) and kingfish Lanhoun samples (14.8 ± 1.0 - 23.4 ± 6.9 g/100g). The difference in the lipid contents of the two species of fish is due to the fact that kingfish is a fatty fish while cassava fish is a lean fish.

Thiobarbituric acid (TBA) contents varied from 10.9 ± 2.1 to 12.5 ± 0.4 malonaldehyde/kg for all Lanhoun samples. No significant difference ($p > 0.05$) was observed in the thiobarbituric acid content for all Lanhoun samples. The current values of thiobarbituric acid recorded on Lanhoun samples were higher than values of 5.3 to 6.1 mg malonaldehyde/kg for cassava fish, and 7.2 to 9.4 mg malonaldehyde/kg for kingfish reported by Anihouvi *et al.* (2006) and Abbey *et al.* (1994). However, lower value of TBA of 3.96 ± 0.12 mg malonaldehyde/kg was reported by Oduor-Odote and Obiero (2009) on smoked fish. Thiobarbituric acid number provides an indication of onset of lipid oxidation (Hernández-Herrero *et al.*, 1999). There are no set standards in literature as far as we know that indicate acceptable levels of TBA in fermented fish products. However, for meat products, TBA level should be lower than 5 mg malonaldehyde/kg (Gigaud, 2006).

The total volatile nitrogen (TVN) content of samples varied between 191.7 ± 47.0 and 225.8 ± 80.2 for cassava fish, and 193.3 ± 26.1 and 296.2 ± 80.0 mg N/100 g for Lanhoun obtained from kingfish. The highest values of TVN contents were recorded for the market samples of Lanhoun prepared with kingfish in aerobic and semi aerobic fermentations conditions. These values of TVN agreed with those reported by Anihouvi *et al.* (2006) on Lanhoun samples made with cassava fish (294.5 ± 29.8 mg N/100 g) and kingfish (374.5 ± 15.3 mg N/100 g). Level of TVN in fish is used as spoilage indicator due to bacterial and enzymatic action leading to proteins degradation (Hernandez-Herrero *et al.*, 1999; Anihouvi *et al.*,

2006). It was suggested that white-fleshed fish is fresh when TVN contents were below 200 mg N/kg. The fish would be rejected for human consumption when the TVN content exceeds approximately 500 mg N/kg.

There was significant difference ($p < 0.05$) between the acidity index of cassava fish Lanhouin ($0.68 \pm 0.2 - 0.89 \pm 0.2$ g oleic acid/100g) and kingfish Lanhouin ($1.85 \pm 0.4 - 2.52 \pm 0.74$ % oleic acid). These values of acidity index were lower than those reported for a previous study on market samples of Lanhouin (Anihouvi *et al.*, 2006). High acidity index content is an indication of microbial spoilage and enzymatic such as lipases activities (Hernández-Herrero *et al.*, 1999; Anihouvi *et al.*, 2006).

5) Results for Kong

The results of biochemical and nutritional analysis of Kong samples are summarized in Table 6.

Table 6: Results for biochemical and nutritional analysis of Kong samples

Parameter and unit of measurement	Responsible partner and lab	Variety Process/Raw material/Area (Mean \pm SD)		
		Zone 1: Ziguinchor		Zone 2: Dakar
		Well dried smoked (n=12)	Wet smoked (n=5)	Wet smoked (n=15)
Protein (g/100g dwb)	UCAD	76.06 \pm 6.10 ^b	79.54 \pm 6.37 ^a	80.05 \pm 6.28 ^a
Lipid (g/100 g dwb)	UCAD	13.41 \pm 6.97 ^b	9.98 \pm 5.74 ^a	8.54 \pm 4.98 ^a
TVN (mg/100g)	UCAD	28.44 \pm 10.50 ^b	22.96 \pm 1.42 ^a	19.15 \pm 5.62 ^a

dwb: dry weight basis; n=number of samples; within one line different superscript letters indicate significant differences ($p < 0.05$)

The TVN values are consistent with unaltered fish (<40 mg/100g). Thus with respect to this criterion these samples are suitable for consumption with the exception of five samples of dried Kong. But the TVN value for smoked and well dried Kong is higher and statistically different from the wet smoked Kong. In the other hand, protein content of dried smoked Kong is lower than that of wet smoked one. This difference shows informations about the unstable nature of the wet smoked Kong that continues to change (alteration) during storage.

According to water content in wet smoked Kong, producers use a daily production in order to control end-product in market. However it seems important to improve in markets, the way of handling and storage conditions in order to get more shell-fife to smoked Kong. Energy intake is evaluated from the lipid and protein expressed on dry matter. The average energy intake of both types of smoked Kong is not significantly different when they are expressed relative to dry matter (424.69 \pm 87.13 kcal/100g for dry smoked Kong and 402.53 \pm 73.54 kcal/100g for the wet one).

6) Conclusion

➤ KITOZA

Biochemical composition of Kitoza varies greatly. The mean of lipid and protein contents of Kitoza for beef and pork indicated that they have interesting nutritional characteristics. TBARS value provides indication on lipid oxidation. In meat, quality defects are perceptible for values of 2-3 mg/kg and fresh meat is unfit for consumption when TBARS values are higher than 5 mg/kg (Gigaud, 2006). TBARS values of Kitoza are about 3.5 mg/kg but with samples higher than 10 mg/kg. In comparison, TBARS of Kilishi (salted/dried beef meat product) is from 1.53 to 2.01 mg/kg during 60 weeks of storage at ambient temperature. The reengineering of the process could improve the quality regarding the TBARS values.

➤ LANHOUIN

The study showed that protein contents, lipid contents and acidity index of samples were within acceptable limits but thiobarbituric acid and total volatile nitrogen contents were very high as a reflection of some forms of spoilage. The reengineering of the processing method could help to improve the quality of Lanhouin regarding the parameters such TBA, TVN and other.

➤ KONG

Biochemical composition of smoked Kong is satisfactory for consumption and results show that the difference in the process does not affect the nutritional value of end-products. Analyses show the impact of long smoking time on protein's degradation and increased TVN value. However shelf life is reduced in wet smoked Kong. Even dried smoked kong can revealed a higher level of TVN during storage. This can be longer by improving storage condition and handling in markets with an appropriate packaging.

7) Bibliography

➤ KITOZA

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➤ **KONG**